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Growth of Suppressed Grand Fir and Shasta Red Fir in Central Oregon After Release and Thinning — 10-Year Results

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Abstract

A 43-year-old, even-aged stand of advance reproduction of grand fir and Shasta red fir in central Oregon responded to release and thinning with diameter and height growth two to three times the prerelease rate. The response began immediately after the overstory was killed with 2,4-D. Diameter growth during the second 5 years after release increased significantly over that of the first 5 years. Differences in spacing had no effect on growth. Increased growth after release suggests that saving advance true fir reproduction is desirable under certain conditions.

Keywords: Growth response, thinning effects, even-aged stands, release, central Oregon, grand fir, *Abies grandis*, Shasta red fir, *Abies magnifica*.

Introduction

Many mixed conifer forests in eastern Oregon and Washington consist of a mature or overmature overstory and a suppressed understory of saplings and poles. Although true firs are an important component of these mixed conifer forests, no information is available on their long-term growth and yield under various spacing and thinning regimes.

In 1970, a study was begun in a suppressed, even-aged stand of grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.) and Shasta red fir (*A. magnifica* var. *shastensis* Lemm.) in central Oregon. The purpose was to obtain data on growth of the two species at several initial spacings and under a progressive thinning schedule. This paper reports study results after 10 years. It supplements an earlier report of results for the first 5 years (Seidel 1977).

Study Area and Methods

The study site is on the Pringle Falls Experimental Forest in the Deschutes National Forest near Bend, Oregon; the site and the timber stand are described in an earlier report (Seidel 1977).

The study consists of two closely related parts. One is an initial spacing experiment, testing growth at four spacings (6-, 12-, 18-, and 24-feet) in variable-area plots created by thinning in 1970. Each spacing is replicated twice, making a total of eight plots. Twenty-four trees were selected for measurements in each plot; plot size, including buffer strips, ranged from 0.14 acre to 0.64 acre, depending on spacing. No additional thinning will be done in these plots.

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The second part is a progressive thinning experiment with fixed-area plots similar to O'Conner's design (1935). Eight 0.25-acre plots were thinned to 6-foot spacing in 1970. The plan calls for subsequent thinning based on diameter growth. When diameter growth of 10 percent of trees on all eight plots is 0.1 inch or less than growth the previous year, six of the eight plots will be thinned to 12-foot spacing. When growth on the plots with 12-foot spacing slows to the same degree, four plots of the six will be thinned to 18-foot spacing. Thinning will continue on this pattern until there are two plots at each of the four spacings in variable-area plots. This plan will eventually permit comparison of volume growth and yield between the initial spacing, variable-area plots and progressively thinned, fixed-area plots. After 10 years, the fixed-area plots remain at 6-foot spacing.

The lodgepole pine overstory was killed in 1970 with 2,4-D ((2,4-dichlorophenoxy) acetic acid) to release the fir understory without logging damage and provide partial shade for a few years after release. Two-hundred-fifty fir seedlings near the plots were transplanted onto the fixed-area plots to improve spacing.

Height of all plot trees was measured to the nearest 0.1 foot and diameter at breast height (d.b.h.) of trees 0.6 inch or larger to the nearest 0.1 inch in 1971, 1975, and 1980. Diameter was measured annually on a 10-percent random sample of trees on the fixed-area plots. In 1976, 50 trees of each species were randomly chosen from the buffer strips and cut at the groundline for measurements of diameter growth during the 5 years before release and the 5 years after release. In 1976, the 5-year prerelease height growth was measured by counting whorls of all trees in the variable-area plots and the 10-percent sample in the fixed-area plots. Crown diameter and height to live crown were measured on 10 trees per plot on the variable-area plots in 1971, 1975, and 1980.

Average height of trees on the eight fixed-area plots was 4.6 feet after thinning and ranged from 3.8 to 5.6 feet on the variable-area plots (table 1). Average d.b.h. of trees of measurable size was about 1 inch. Of the trees in the fixed-area plots, 59 percent were grand fir compared with 81 percent in the variable-area plots.

Differences in diameter and height growth between species, periods, and initial spacings were analyzed using split-plot analyses of variance in a completely randomized design at the 0.05 probability level. Height growth was also subjected to analysis, using height before release and thinning and 5-year prerelease height growth as covariates. No analyses were applied to data from the fixed-area plots because they are all at the same 6-foot spacing.

Table 1 — Characteristics of grand fir — Shasta red fir plots after thinning in 1970 and 5 and 10 years later

Plots and spacing	Species composition: Grand fir	Species composition: Red fir	Number of trees	Trees less than 0.6-inch d.b.h.	Trees less than 0.6-inch d.b.h.	Quadratic mean diameter[1]	Average height	Basal area	Total volume
Feet	---*Percent*---		*Per acre*	*Number per acre*	*Percent*	*Inches*	*Feet*	*Square feet per acre*	*Cubic feet per acre*
After thinning, 1970:									
Fixed-area plots —									
6 x 6	59	41	1,169	817	70	1.2	4.6	2.8	20.6
Variable-area plots —									
6 x 6	81	19	1,200	975	81	1.2	3.8	1.7	11.5
12 x 12	79	21	304	158	52	1.2	5.6	1.2	7.7
18 x 18	92	8	134	103	77	0.9	4.3	0.2	1.1
24 x 24	71	29	76	63	83	1.0	4.1	0.1	0.5
1975:									
Fixed-area plots—									
6 x 6	59	41	1,114	498	45	1.5	6.7	8.5	65.4
Variable-area plots —									
6 x 6	81	19	1,200	800	67	1.5	5.3	5.4	38.3
12 x 12	79	21	304	95	31	1.8	8.0	3.6	25.4
18 x 18	92	8	134	61	46	1.4	6.5	0.8	5.6
24 x 24	71	29	76	33	43	1.3	6.0	0.4	2.5
1980:									
Fixed-area plots —									
6 x 6	60	40	1,039	280	27	2.2	8.4	19.9	173.6
Variable-area plots —									
6 x 6	81	19	1,200	550	46	1.9	6.5	12.8	100.5
12 x 12	80	20	298	44	15	2.6	10.1	9.3	81.8
18 x 18	92	8	132	11	8	2.1	9.1	3.0	24.8
24 x 24	69	31	76	11	15	2.0	8.3	1.4	10.2

[1] All trees 0.6-inch d.b.h. and larger.

Results

Diameter Growth

Release had a marked effect on rate of diameter growth of the fir understory. The average growth of both species during the 5 years before release (measured on trees cut in buffer strips) was about 0.04 inch per year. Growth increased nearly threefold, to 0.11 inch per year, in the 5 years after release. The response occurred during the first year, averaging 0.13 inch.

During the first 5-year period diameter growth was not affected by variations in spacing. Annual growth averaged 0.16 inch on the 12-, 18-, and 24-foot spacings and 0.15 inch on the 6-foot spacing (table 2). On the eight fixed-area plots, which remained at 6-foot spacing, periodic annual diameter growth averaged 0.15 inch, and there was no significant difference between grand fir (0.14 inch per year) and red fir (0.16 inch per year).

During the second 5-year period, diameter growth increased significantly ($P<0.05$) above that of the first period. Increases ranged from 20 percent at the 6-foot spacing to 44 percent at the 18-foot spacing. Differences among spacings were still not significant, although growth at the 12- and 18-foot spacings was 0.22 to 0.23 inch per year compared to 0.18 inch at the 6-foot spacing (table 2). Diameter growth in table 2 may not agree with differences between mean diameters at the beginning and end of growth periods shown in table 1 because average diameters at each measurement are based on trees 0.6 inches d.b.h. or larger at the time, but growth is based only on trees of measurable size in 1970 and 1975. Differences between the two species again were not significant.

Table 2 — Periodic annual increment and mortality of grand fir and Shasta red fir saplings during two 5-year measurement periods after release and thinning in 1970 when trees were 43 years old

		Basal area growth			Total volume growth		
Plots and spacing	Diameter growth[1]	Net	Mortality	Gross	Net	Mortality	Gross
Feet	*Inches*	— *Square feet per acre* —			— *Cubic feet per acre* —		
From age 43 to 48 (1971-75):							
Fixed-area plots —							
6 x 6	0.15	1.13	0.01	1.14	8.9	0.1	9.0
Variable-area plots —							
6 x 6	.15	.74	—	.74	5.4	—	5.4
12 x 12	.16	.50	—	.50	3.6	—	3.6
18 x 18	.16	.14	—	.14	.9	—	.9
24 x 24	.16	.06	—	.06	.4	—	.4
From age 48 to 53 (1976-80):							
Fixed-area plots —							
6 x 6	.17	2.28	.08	2.36	21.6	.7	22.3
Variable area plots —							
6 x 6	.18	1.47	—	1.47	12.4	—	12.4
12 x 12	.22	1.14	.03	1.17	11.3	.2	11.5
18 x 18	.23	.44	—	.44	3.9	—	3.9
24 x 24	.20	.20	—	.20	1.6	—	1.6

[1]Arithmetic mean diameter growth of trees 0.6-inch d.b.h. or larger at beginning of each 5-year period and living through the period.

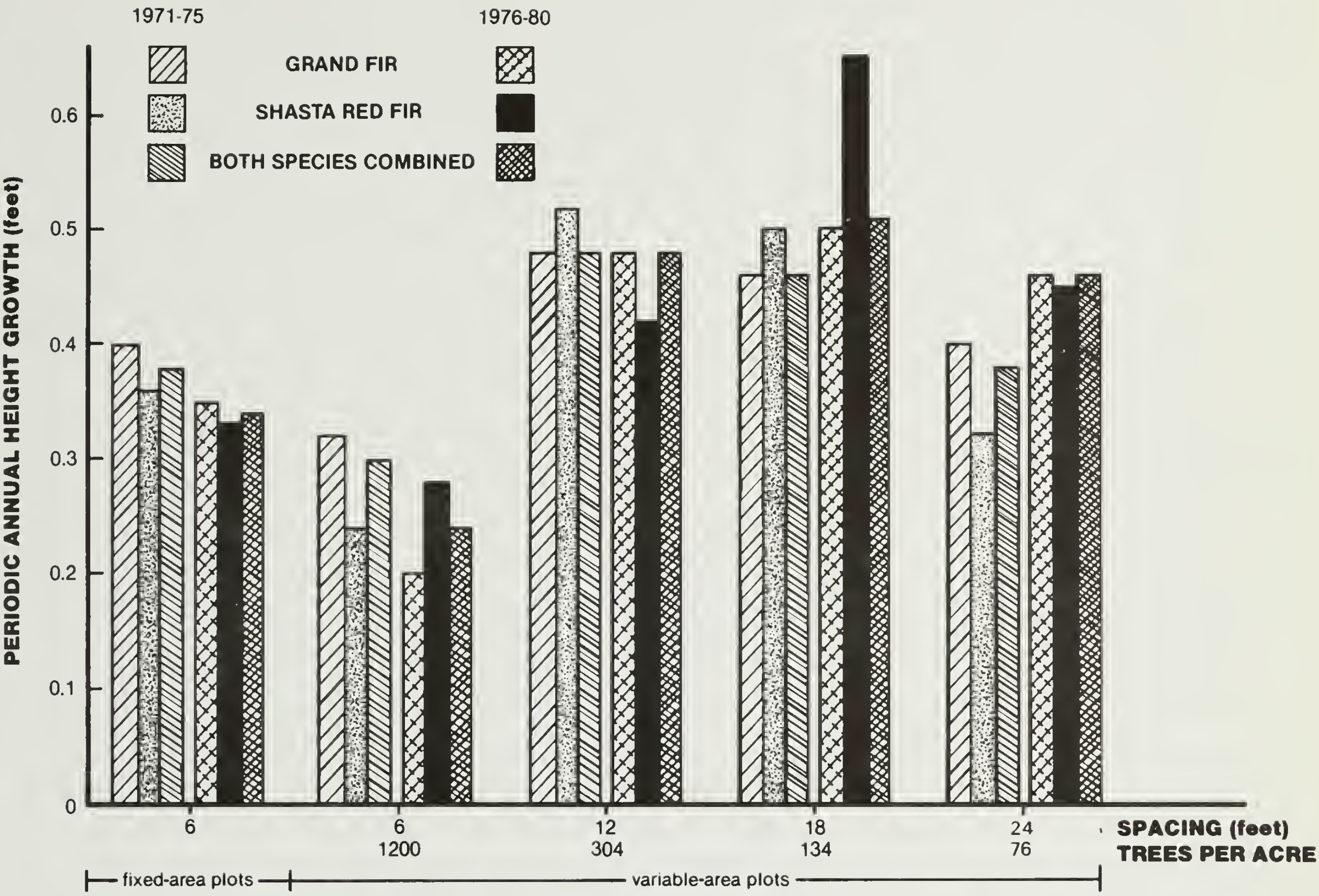

Figure 1. — Periodic annual height increment after release, by species, spacing, and growth period, based on growth of all trees living through each 5-year period. The number of trees per acre in the fixed-area plots varied over time because of mortality but was not more than 1,200.

Height Growth

Height growth did not differ significantly according to species or spacing, or between the two 5-year periods. Use of initial height and prerelease height growth as covariates did not produce any significant differences among spacings. Average annual growth was slowest at the 6-foot spacing during both periods and fastest at the 12- and 18-foot spacings (fig. 1). During the second period, height growth at the 6-foot spacing was slightly less than in the first period, while growth at the wider spacings was somewhat greater. Height growth of individual trees varied widely, ranging from 0 to 7 feet during the 10 years.

The trees responded to release the first growing season after release, in contrast to a delay of 5 years for suppressed red firs in California (Gordon 1973). The growth rate doubled from about 0.2 foot annually before release to about 0.4 foot per year after release.

Growth in Basal Area and Volume

Growth in both basal area and total cubic volume was small during the first 5 years but increased significantly ($P<0.05$) during the second 5 years as more trees reached measurable size. Annual volume increment more than doubled, from 9.0 to 22.3 cubic feet per acre, on the fixed-area plots during the second period (table 2). Average volume and basal area growth in the 6-foot-spaced variable-area plots was much less than growth in the fixed-area plots because one variable-area plot had only 33 percent trees of measurable size compared to 73 percent on the fixed-area plots.

Mortality

Much of the mortality was transplanted seedlings. All but 8 of the 111 that died during the first 5 years were transplanted trees. During the second period, 70 additional trees died; most were less than 3 feet tall. No snow damage was observed after release and thinning, except for a few trees with small crowns that were growing in dense clumps before thinning.

Discussion

The large and rapid response to release, in terms of both diameter and height growth, may have been because most of the trees in this study were vigorous, with live crown ratios greater than 40 percent. Basal area and volume increment more than doubled during the second 5-year period on the fixed-area plots and can be expected to increase rapidly during the next 10 to 20 years as average stand diameter and height increase and all trees attain measurable size.

Because of their shade tolerance, many true fir seedlings and saplings retain relatively full crowns, even though they are suppressed, and thus can respond rapidly to increased growing space as did the trees in this study. Results of another study in central Oregon (Seidel 1980a) indicate that suppressed advance reproduction with live crown ratios of at least 50 percent, showing rapid height growth before release are best able to respond to release. The height advantage of advance reproduction can be determined if average heights and height-growth rates of both planted seedlings and advance reproduction are known (Seidel 1980b). In addition, using a two-stage overstory removal, with about 5 years between cuttings, on hot, dry sites, as suggested by Ferguson and Adams (1979), enables trees to adjust to their new environment.

When deciding whether to save advance reproduction or clearcut and plant, managers should also consider the possibility of animal damage to seedlings and the probability that heart rots will cause decay in the future. There is still some uncertainty that heart-rotting fungi will be reactivated by wounds in advance reproduction of true fir, but Filip and Aho (1978) have identified conditions where a high risk of future decay exists for white fir (*Abies concolor*) in the Fremont National Forest. These conditions are: (1) white fir overstory infected with Indian paint fungus (*Echinodontium tinctorium*), (2) advance white fir regeneration that has been suppressed for more than 50 years, (3) advance reproduction that has numerous wounds, and (4) advance reproduction of low vigor because of poor site. They feel if three or more of these conditions are present in a stand, the advance white fir regeneration has a high potential for developing serious decay.

A decision to save and manage the advance reproduction requires the use of logging methods and slash disposal techniques designed to reduce loss and damage to the understory. Barrett and others (1976) have shown that it is possible to preserve adequate numbers of understory ponderosa pine (*Pinus ponderosa*) saplings by marking the potential crop trees before logging and by using unconventional slash disposal equipment, such as a front-end grapple mounted on a rubber-tired tractor. Similar techniques should be applicable to mixed conifer stands where topography permits tractor logging.

Metric Equivalents

1 acre = 0.405 hectare
1 foot = 0.3048 meter
1 inch = 2.54 centimeters
1 mile = 1.61 kilometers
1 square foot = 0.0929 square meter
1 square foot/acre = 0.2296 square meter/hectare
1 tree/acre = 2.47 trees/hectare
1 cubic foot = 0.0293 cubic meter
1 cubic foot/acre = 0.0700 cubic meter/hectare

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